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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

<u>Reference No. 51-94</u>

Hydrographic Survey in the Boston Area
Results of HAZEL III Cruises
5 and 6

Interim Report No. 5
Submitted to Geophysics Branch, Office of Naval Research
Under Contract N6onr-27712 (NR-084-008)

November 1951

APPROVED FOR DISTRIBUTION ____________________
Director

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The Contractor shall furnish the necessary personnel and facilities for and, in accordance with any instructions issued by the Scientific Officer or his authorized representative, shall conduct an oceanographic investigation of Boston Harbor.

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Introduction

During the 5th and 6th cruises of the HAZEL III, 20-24 August and 10-13 September 1951, measurements of the distribution of temperature and salinity and, hence indirectly, density and sound velocity, were made in the Boston Harbor area. These measurements were part of a continuing series of observations under the Inshore Survey Program, earlier cruises having been undertaken 2-9 May and 19-30 June 1951.

Bathythermograms were taken in Cape Cod and Massachusetts Bays along the sections indicated in Figure 1. Measurements of temperature, salinity, and transparency were made at the points of observation indicated by letters in Figure 1. Parts of the section from Boston Inner Harbor out to the longitude of the Boston Light Vessel were occupied several times in the course of the two cruises to ascertain the affect of various stages of the tide on the distribution of the variables. It had been suggested that a wedge of more nearly homogeneous water might penetrate up the channel with a rising tide and recede with a falling one, hence producing better sonar conditions for a hydrophone or transducer close to the bottom near the time of high water.

Temperature and Salinity at the Surface

The distribution of temperature at the surface, 20-24 August, is shown in Figure 2. The temperature ranged from slightly less than 64°F. in the offing of Salem to a high of more than 70°F. over the Wellfleet Shoals. The temperature in the upper reaches of the Inner Harbor was greater than 66°F., diminishing to a minimum in North Channel and Broad Sound, thence increasing offshore. A puddle of warm water, maximum 66°., appeared to reside in the offing of Boston Harbor, extending from east of the Brewsters southeasterly to off Scituate. The surface temperature of Cape Cod and southern Massachusetts Bay was in general 65° ± 1°F. Exceptions were an increase to greater than 70°F. over the Wellfleet Shoals and a decrease to less than 60°F. north of the tip of Cape Cod. The surface temperature had, in general, increased 8°F. since the previous cruise during the last half of June.

The surface salinity in the vicinity of Boston varied from a low of less than 29 ‰ in the Inner Harbor to 30 ‰ in President Roads to greater than 31.6 ‰ over Stellwagen Bank. The surface salinity in Cape Cod Bay ranged between 31.1 and 31.4 ‰, Figure 3. In the offing

of Boston and in Cape Cod Bay, the surface salinity had increased 0.5 to 0.7 ‰ since the measurements during the last half of June.

Temperature Sections Across Cape Cod and Massachusetts Bays

The distribution of temperature along the sections in Figure 1 are shown in Figure 4. In Section I, there was a weak negative temperature gradient in the upper 30 feet, below which there lay a strong gradient, ca 5°F./25', from 30 feet to the bottom. In Section II, there was a weak negative gradient near the surface, below which lay a strong gradient, maximum 10°F./20' to a depth of about 60 feet near the center of the section. The gradient was less strong but lay deeper at either end of the section. Below the strong gradient, there lay a weak negative gradient. Similar conditions prevailed in Section III. In Section IV, from Race Point to the center of Stellwagen Bank, a negative gradient of 15°F. extended essentially from the surface to 80 feet, the depth of Stellwagen Bank. Where the depths were greater than 80 feet, a weak negative gradient prevailed below that depth at the rate of about 2°F./100'. In Section V, the strong negative gradient, approximately 10°F./25', prevailed just below the surface, being strongest and shallowest just west of Stellwagen Bank. This strong gradient was limited to depths above 75 feet, below which a much weaker gradient continued to the bottom.

Distribution of Temperature, Salinity, Density, and Sound Velocity in Boston Harbor Approaches

In the section between Minots Light and Manchester, Figure 5, a weak negative gradient of one or two degrees Fahrenheit was confined to the upper 40 feet, below which depth a strong gradient, 10°F./25', extended to 65 feet; below this the gradient tapered off to about 4°F./25'. The total change in temperature between the surface and bottom at 150 feet was 18°F.

Salinity increased with depth more or less regularly from about 31.3 ‰ at the surface to about 32.1 ‰ at 100 feet. There was an indication of a weak intrusion of fresher water from the east at the northern end of the section and a much weaker indication of an exodus of diluted sea water from Boston Harbor over the southern half of the section.

The density increased from about 22.2 σ_t at the surface to > 24.5 σ_t at 100 feet, with the density gradient being strongest at mid-depths.

Sound velocity decreased from about 4960 feet/sec. at the surface to about 4870 feet/sec. at 100 feet, which is sufficient to refract a sound beam of 0° inclination at the surface to 10.9° at 100 feet; in consequence, a sound ray tangent at the surface would strike the bottom at a range of 350 yards.

In the section normal to the one described above Figure 6, from Boston Inner Harbor out through North Channel to the longitude of Boston Light Vessel, the temperature decreased at the surface from 70°F. in the Mystic River to < 66°F. at Deer Island and North Channel, then increased to 67°F. at the outer end of the section. In the Inner Harbor, the temperature decreased about 4°F. between the surface and the bottom at 40 to 50 feet. In President Roads, the gradient weakened, then increased sharply in North Channel to about 10°F. between the surface and 50 feet. Offshore, the gradient deepened slightly with a weaker gradient underlying the stronger one at mid-depth.

The surface salinity increased from < 28.25 ‰ in Mystic River to 30.0 ‰ in President Roads, to 31.0 ‰ in North Channel and to > 31.25 ‰ at the outer end of the section. Salinity increased between the surface and bottom about 2 ‰ in Mystic River, about 1.5 ‰ in the Inner Harbor, about 0.5 ‰ in President Roads where the gradient was at a minimum, and about 0.75 ‰ in the offshore part of the section.

Density increased from < 19.5 σ_t at the surface in the Mystic River to greater than 22.0 σ_t in North Channel. The density increase with depth was 1.5 units of σ_t in Mystic River, little more than 0.5 units of σ_t in President Roads, 1.0 units of σ_t in North Channel, and about 2.5 units of σ_t at the outer end of the section.

The sound velocity gradient with depth was slight in the Inner Harbor and President Roads, but increased abruptly in the North Channel to conditions similar to those described for the Minots-Manchester section.

Changes in the Temperature and Salinity Distribution in the Ship Channel during the Tidal Cycle

The figures mentioned in the text above indicate that in North Channel and seaward below 50 feet there appears to be a layer of water with slightly decreasing temperature and slightly increasing salinity, hence slightly decreasing sound velocity. The question arose as to whether this layer containing a weak gradient intruded landward during the rising tide and receded seaward during the falling tide sufficiently to influence sonar gear near the bottom. In a long narrow estuary with gradually increasing depth offshore and a large rise and fall in tide, such might be expected to happen. Could we expect such a circumstance to occur in the approaches in Broad Sound? Figures 7 and 8 show the distribution of temperature, salinity, density, and sound velocity near the time of low water and high water on 12 and 13 September 1951. The strong gradient in temperature and sound velocity which impinged on the bottom between Station Bh and Bl exhibited essentially no change during the course of the tidal cycle. Hence, no improvement in the sound conditions can be predicted for any phase of the tide during the summer time.

Attendent Precipitation and Stream Flow Data for August

Precipitation and stream flow data for New England are available from the Geological Survey Water Bulletin for August 1951. Precipitation was slightly above normal in the region during August, being 3.83 inches for Massachusetts or 106% of normal.

Stream flow was considerably above normal throughout the district.

Ground water levels declined seasonally. Water levels were in general well above average for this time of year. The water level was up 1.12 feet from the August average. The net change in Middlesex County was -0.70 feet since July, and + 2.25 since last August.

Ambient Noise

On several occasions in September a preliminary attempt was made to listen to ambient noise with a C-23 hydrophone (100-6,000 cycles) connected to a JN-1 receiver. The only

sounds heard were those characteristic of swiftly moving water; i.e., "water noises" with some clicking sounds heard when the hydrophone was close to the bottom. These noises were probably produced by stones knocking together. The intensity of the "water noises" was comparable to the screw noises of a destroyer or freighter roughly 1.5 miles distant. No sounds of biological origin were discriminated.

List of Figures

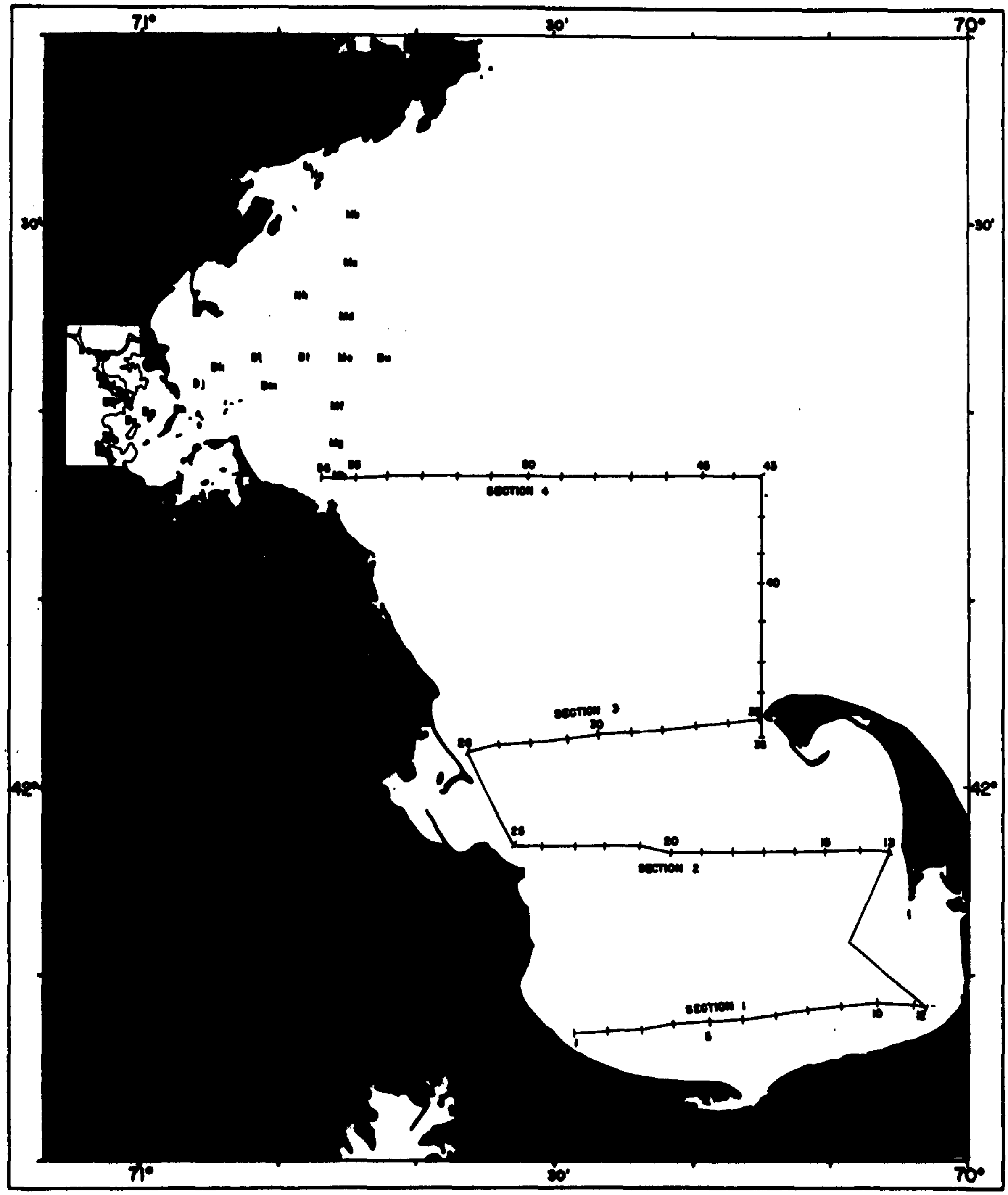

Fig. 1 Track chart and station locations, HAZEL III - Cruises 5 and 6, August and September 1951.

Fig. 2 Distribution of temperature (°F.) at the surface, HAZEL III - Cruise 5, August 1951.

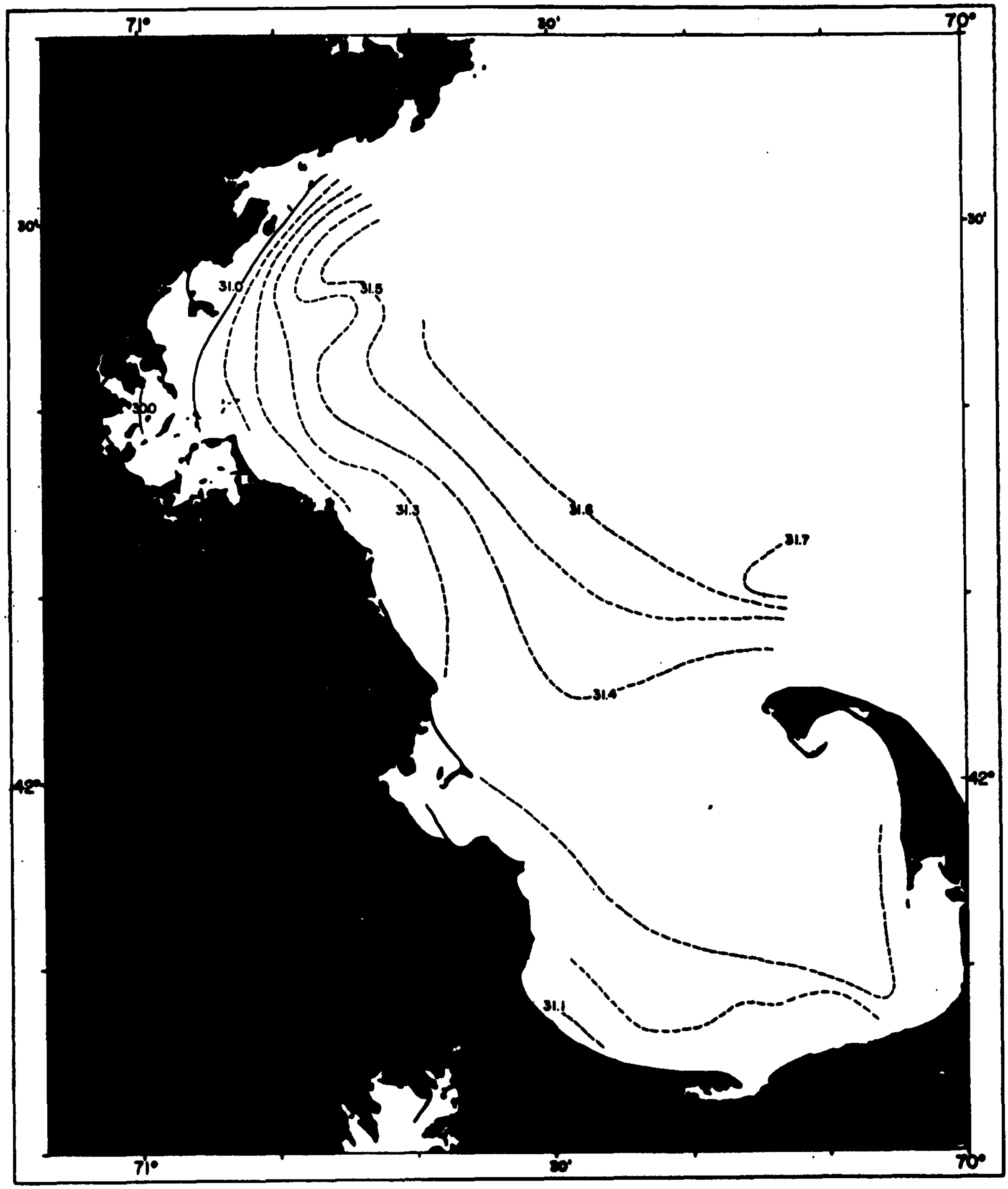

Fig. 3 Distribution of salinity (°/oo) at the surface, HAZEL III - Cruise 5, August 1951.

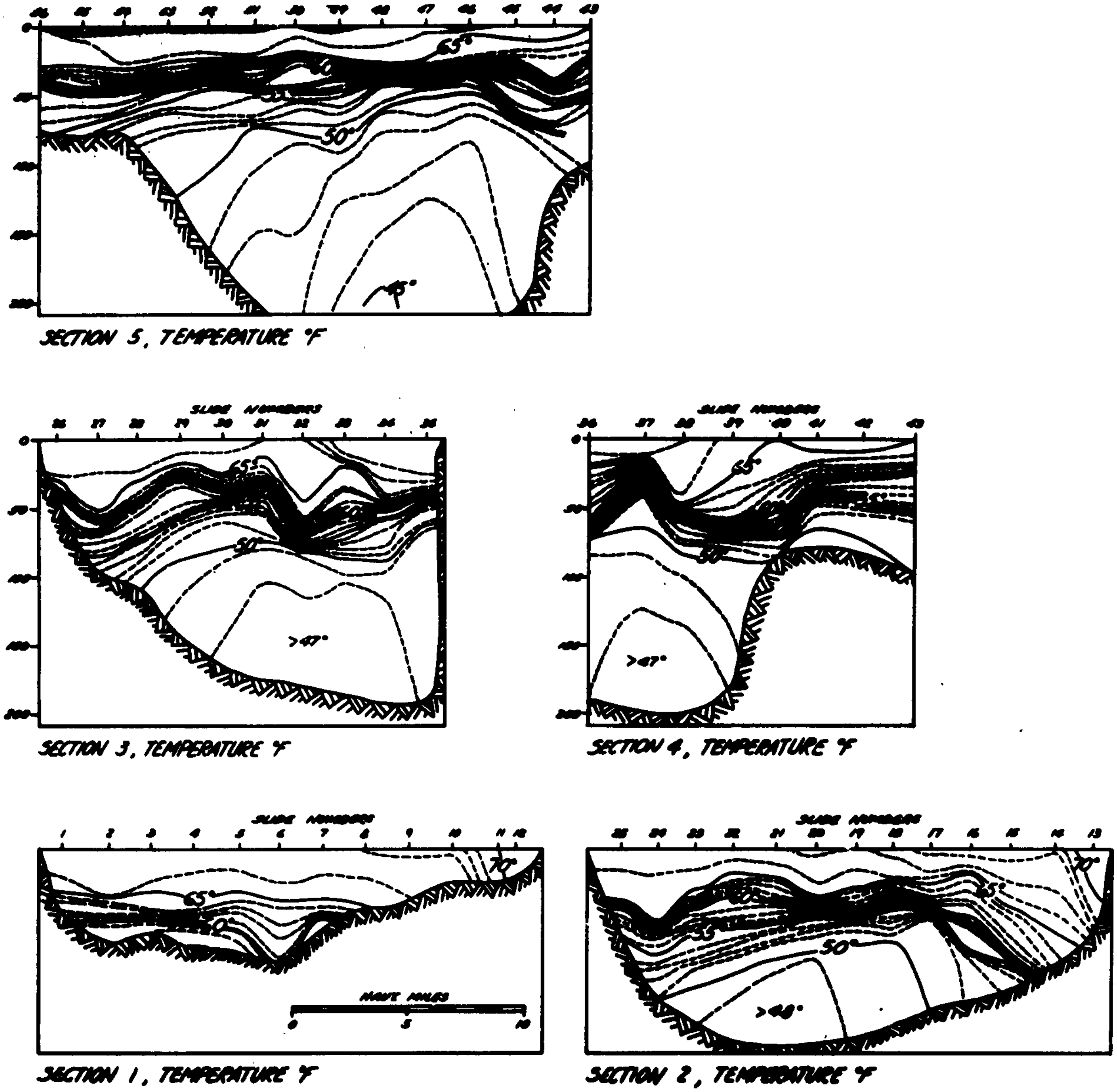

Fig. 4 Distribution of temperature (°F.) along sections in Cape Cod and Massachusetts Bays, HAZEL III - Cruise 5, August 1951.

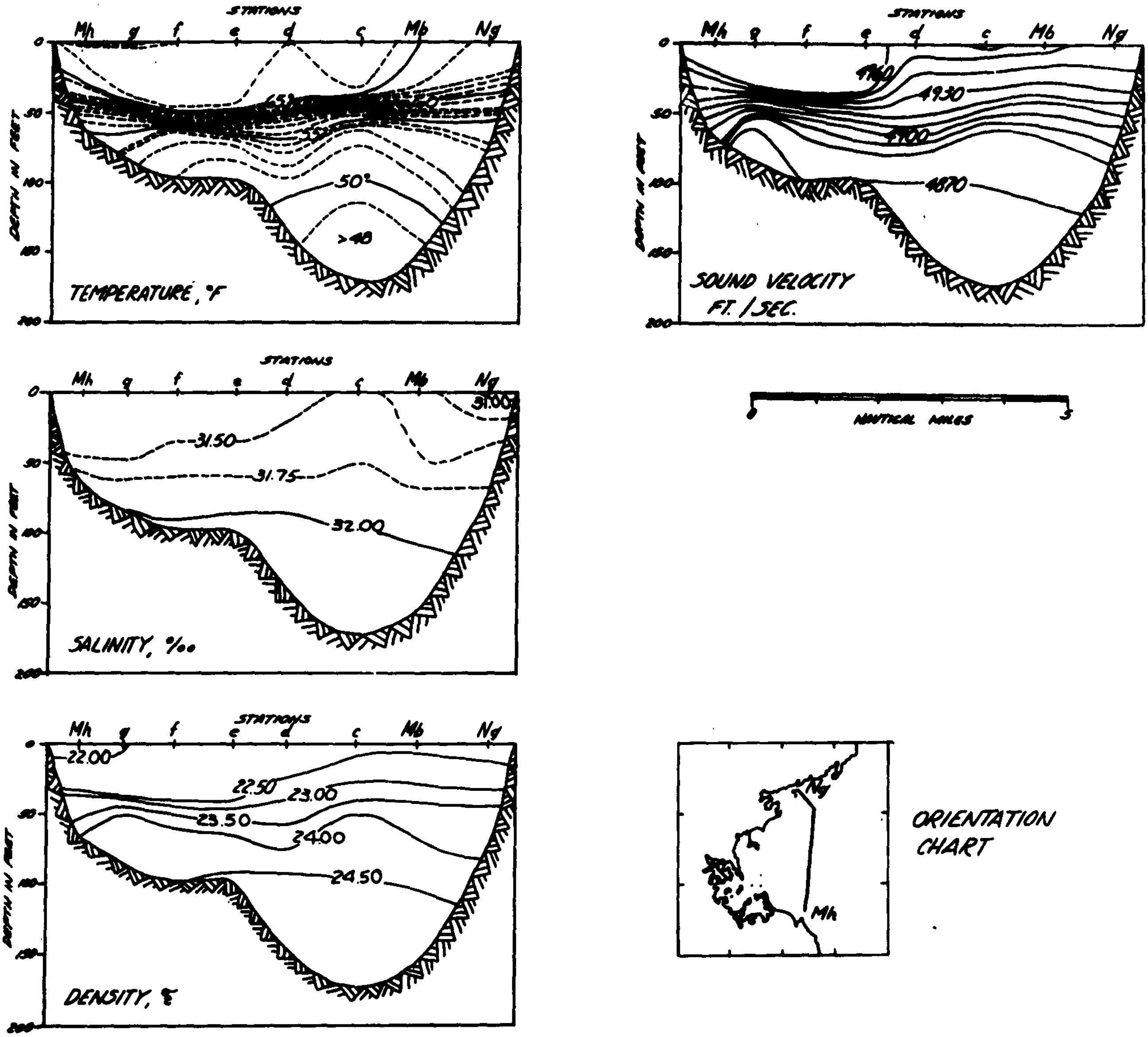

Fig. 5 Distribution of temperature, salinity, density, and sound velocity in the section Minots Light to offing of Manchester, HAZEL III - Cruise 5, August 1951.

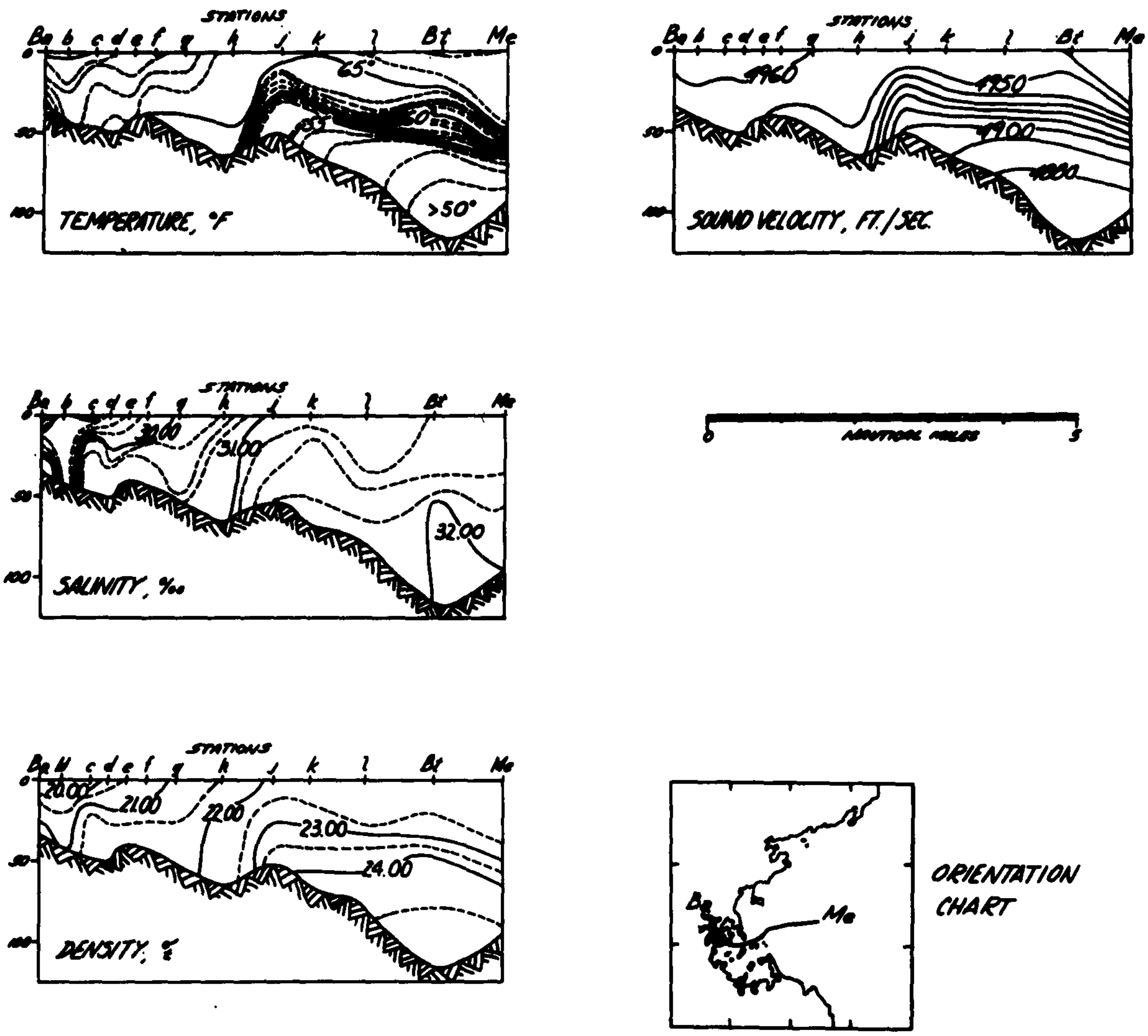

Fig. 6 Distribution of temperature, salinity, density, and sound velocity in the section Chelsea River to longitude of Boston Light Vessel, HAZEL III - Cruise 5, August 1951.

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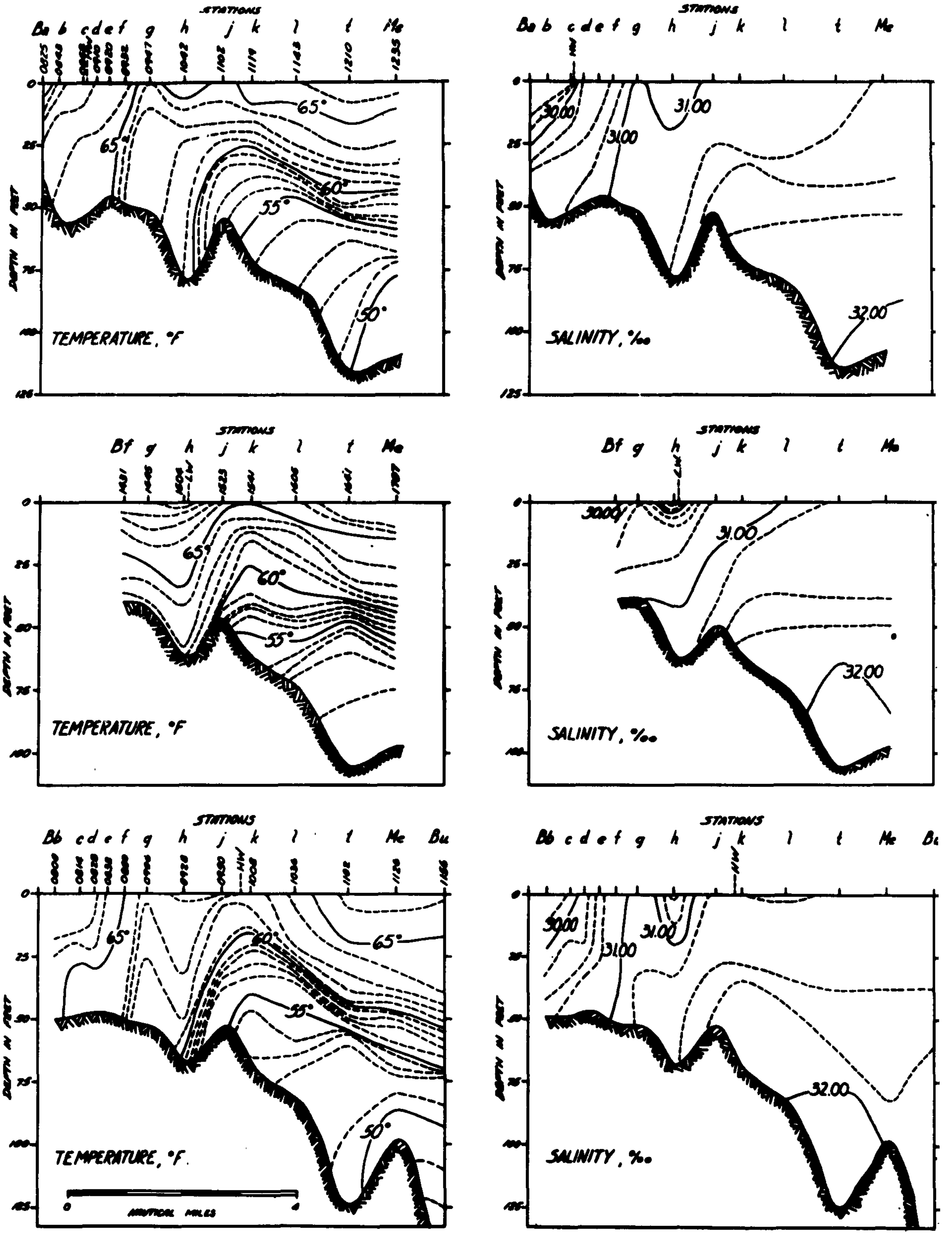

Fig. 7 Distribution of temperature and salinity near time of high water (upper figures) and low water (middle figures) on 12 September and high water (lower figures) on 13 September 1951. HAZEL III - Cruise 6.

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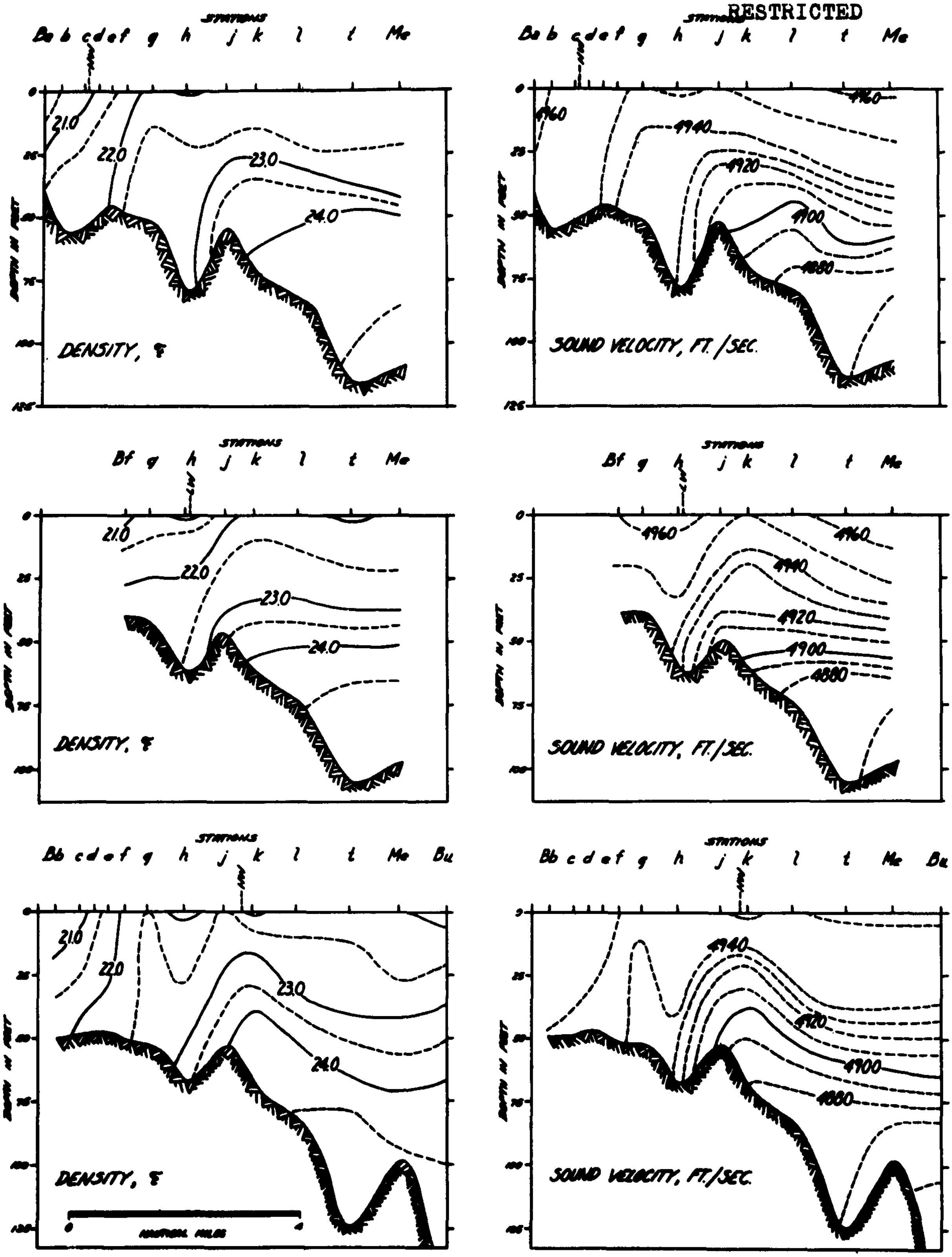

Fig. 8 Distribution of density and sound velocity near line of high water (upper figures) and low water (middle figures) on 12 September and high water (lower figures) on 13 September 1951. HAZEL III - Cruise 6.

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